

## **SECTION 2.0**

### **SYSTEM DESCRIPTION**

The FAA is planning to replace the current air/ground (A/G) communications system with a new system that will increase spectrum capacity in the VHF aeronautical band, support voice and data communications, and enhance other characteristics of the A/G communications link. The new radios for this system will be based on currently available digital radio technology and new VHF radio standards when adopted by ICAO. The system will provide spectrum-efficient voice and data communications between ground facilities and aircraft in a single flexible integrated system.<sup>27</sup>

The A/G communications system description is provided in this section and is organized as follows:

#### **Section 2.1    Current System Architecture Overview**

(Current system description and drivers for change.)

- 2.1.1    System Elements
- 2.1.2    System Connectivity
- 2.1.3    System Security

#### **Section 2.2    Future Digital VHF A/G Communications System Architecture Overview**

(Future system description and responsiveness to needed current system changes)

- 2.2.1    System Elements
- 2.2.2    System Connectivity
- 2.2.3    System Security

#### **Section 2.3    Transition to Future Digital VHF A/G Communications System**

The FAA has no operational concept document for the existing A/G system; as a result, some of the specifics of the current system architecture are only generally described. The purpose of structuring this system description in two stages is to use the current system description as the foundation for the evolution to the Future Digital VHF A/G Communications System. Section 5.0 provides a description of how users of the system will operate throughout this evolution.

### **2.1    Current System Architecture Overview**

The FAA was organized to provide safe and efficient use of airspace. A major part of that goal is to provide reliable A/G voice and data communications in support of air traffic control and flight

advisory information. The A/G communications system must be provided between an aircraft and those facilities with which the aircraft communicates as it travels in domestic, oceanic, and foreign airspace and in ground operations. The ATC system is characterized by functional areas and operational domains. The future A/G system falls within the communications functional area. Within this functional area, there are six operational domains. These include the tower/airport surface (ATCTs), the terminal area (TRACONs, LCFs, MCFs), domestic en route (ARTCCs), oceanic, flight services, and national traffic flow. Operational descriptions of each of these domains, the user environment, roles and future A/G system applications are provided in Section 5.0, Operational Scenarios. Figure 2-1 illustrates the architecture of the existing A/G radio system.

Insert Figure 2-1, Current A/G Communications Ground System Architecture (old Figure 2-1)

The major facilities supported by the current A/G system are:

- Air Route Traffic Control Centers (ARTCCs)/Area Control Facilities (ACFs)
- Terminal Radar Approach Control Facilities (TRACONs)
- Air Traffic Control Towers (ATCTs)
- Automated Flight Service Stations (AFSSs)/Satellite Flight Service Stations (FSSs)
- Metroplex Control Facilities (MCFs)/Local Control Facilities (LCFs)
- Air Traffic Control System Command Center (ATCSCC)

The current A/G radio system supports communication in three major aeronautical applications categories: Air Traffic Services (ATS); Aeronautical Industry Services (AIS); and Aeronautical Advisory Information Services (AAIS). ATS supports the safety-related services that the International Civil Aviation Organization (ICAO) nation states provide to ensure the safe separation and expedition of planned aircraft movements. Therefore, FAA A/G communications support falls wholly within this category. ATS is further subdivided into ATC and Flight Information Services (FIS).

As indicated in the description of the mission need for change provided in Section 1.0, the current system architecture must be modified to provide improvements required to support future NAS and oceanic air-to-ground communications between pilots and controllers. There are six significant drivers for change in the current A/G system:

1. A/G Communications System Capacity. Demand for access to A/G communications circuits is in proportion to the level of air traffic which has grown steadily. An average rate of 6% percent growth in air traffic has been maintained from 1977-1992 since the last significant increase in communications channels was made available through the introduction of 25 kHz channel spacing. In these 15 years, air traffic has nearly doubled. The demand for A/G frequency assignments is expected to increase 4% annually between Fiscal Year (FY) 1992 and FY 2002.<sup>44</sup> The demand stems from the need to serve increased levels of air traffic and to satisfy new communications applications. The evolution of new services to aircraft, such as broadcast and transmission of new weather services, further contributes to the growth in the demand for A/G communications. Figure 2-2 illustrates the demand for A/G communications growth.

Demand for A/G communications continues to grow because of the increased number of aircraft in already-overtaxed sectors. Since the 1940s, the increase in the air traffic demand has been met by increasing the spectrum capacity through "channel splitting" or decreasing the separation

between frequency assignments. It has long been recognized that the civil aviation requirements for A/G voice communications in the 117.975 - 137 MHz VHF band vary widely from region to region just as the frequency and the number of flights vary. As spacing has decreased from 200 kHz to 100 kHz, 50 kHz and 25 kHz, the problems caused by radio frequency interference between assignments has increased, limiting the effective capacity of the system.

### **Figure 2-2. Air-To-Ground Communications Growth**

Capacity problems are most evident in congested high traffic regions. The A/G voice system is a major contributor to today's operational difficulties in voice communications. One of the prevailing operational difficulties with the A/G system is caused by the frequent need to re-tune radios manually. Figure 2-3 shows a typical flight scenario from Washington, Dulles (IAD) to New York, LaGuardia (LGA) which illustrates the need for

pilots to re-tune radios eighteen times during the course of a routine flight. There are eight frequency changes in the tower/airport surface and terminal environment (Dulles) prior to entering the en route airspace, five frequency changes during the en route phase, and five at the destination airport (LaGuardia).

**Figure 2-3. High Traffic Airspace Demands for Capacity (IAD to LGA)**

The critical nature of the information and services provided by the A/G communications system mandates that the system be operational on a continuous basis. Service to all users

must remain uninterrupted during the transition to any new system. This requirement effectively increases the demand for A/G frequency assignment during transition.

The increased demand for A/G communications services has created capacity problems internationally as well. The new communications system addressing spectrum capacity problems must be adaptable to international standards.

Each of the A/G communications applications categories is allotted separate portions of the frequency spectrum in the 118-137 MHz band. Figure 2-4 illustrates the present allocation of the VHF nav/comm resource.<sup>7,16</sup> The ATC frequencies are further allocated to FIS, AIS, AAIS, emergency, and others, including flight test, instruction, and temporary ATCTs.

2. A/G Communications Infrastructure Support. The VHF and UHF analog radio transmitters and receivers have been operational at existing FAA communications facilities for over 25 years. The UHF transmitters and receivers are currently used by the FAA to control military aircraft. The technology of these radios is aging, and the manufacturer has discontinued making the radio units. As obsolete radio parts fail, the demand to re-engineer radio components increases. The modular design of the radios was useful when facilities were staffed to accomplish repairs to the component level, but staffing levels continue to decline within the FAA and the government. Continued maintenance support of the analog radios is expected to be reasonable for only the next five years.

3. No Data Link Capability. The current analog A/G communications system does not provide data link services. The FAA leases data link services from ARINC, Inc., to provide Pre-Departure Clearances (PDCs) at 30 airports. These services are based on twenty-year-old analog data link technology, and are outdated and spectrally inefficient. They do not include a suitable message priority structure and does not operate at a sufficient speed to meet the ATS data link message timeliness requirements specified in NAS-SR-1000.

The Future Air Navigation System/Communications, Navigation and Surveillance (FANS/CNS) Air Traffic Management concept postulates that, in the future, communications will operate via VHF data link, reserving voice for emergency and non-routine communications. It is necessary that the same current band segment that provides voice be utilized to provide a data link capability. It is assumed that additional spectrum cannot be attained internationally for this function. Additionally, users are requesting early availability of numerous data link applications, based on their successful experience with analog data links.

Insert Figure 2-4, VHF Nav/Comm Resource (Old Figure 2-8)

4. Susceptibility to Radio Frequency Interference. Current A/G communications are disrupted by ever-increasing forms of Radio Frequency Interference (RFI). The effects of interference range from nuisance squelch breaks during the absence of pilot-controller communications to levels of interference that entirely block the use of the RF channel. This causes a safety hazard to operators within and outside of affected sectors, and operations are impacted as controllers are forced to change sector communications to alternate frequencies (if available) during outages. As the RF spectrum becomes more crowded with users of new systems, it is expected that interference to communications channels will increase over time.

5. No Security Mechanism to Guard Against Unauthorized Users. Unauthorized users are those who intentionally transmit in an unauthorized manner on assigned ATC communications frequencies. FAA personnel are tasked to resolve cases of unauthorized use of ATC channels and participate in interagency teams to resolve such cases. The proliferation of accessible communications equipment dictates that mechanisms be introduced to provide increased levels of security into the VHF communications system to protect against this problem. This potentially severe safety hazard cannot be easily overcome by using the present analog system, whereas security mechanisms are generally available using digital systems.

6. Other Deficiencies. Operational difficulties with VHF voice communications systems include the need for repeating control instructions; mistakes in clearances; limited channel capacity; and simplex design operational constraints, including inadvertent simultaneous transmissions on the channel. The current system is susceptible to problems such as misstated or misinterpreted verbal messages, causing confusion and ambiguity about frequency assignments and other messages. Proper A/G connectivity is accomplished by manual radio tuning performed by the pilot. When a new frequency is to be assigned, it is verbally provided to the pilot. A misstatement or misinterpretation of the frequency assigned can result in total loss of communications. This results in higher controller and pilot workload. The use of digital voice and data link will significantly reduce communications and frequency setting errors.

Channel blockage occurs when multiple users transmit simultaneously or when a radio is inadvertently keyed for a sustained period. This latter situation is referred to as a "stuck microphone" and results in complete loss of a channel, thus cutting off communications with all aircraft in the associated sector and compromising safety. The future system will provide for a controller override capability which will mitigate and reduce instances of stuck microphone channel contention.

User addressing is verbal through the use of the flight's call sign (a flight identifier for airline flights or registration number for general aviation). Continuous pilot monitoring is required to identify transmissions directed to the cockpit. Any lapse in monitoring or miscommunication with the wrong aircraft results in the controller making repeated call attempts, thus increasing controller workload. With the use of the digital radios, these other deficiencies can be eliminated

or significantly reduced, thereby increasing communications capability and air traffic safety. The future system will provide addressing and the use of an aircraft (caller) identification which will reduce and virtually eliminate these problems.

Changing traffic patterns due to upgraded runway configurations or other factors may require that radio sites be relocated and new circuits provided. Construction of buildings in the community surrounding the airport may require relocating radio sites to avoid excessive multi-path problems causing serious degradation to the communications channel. In addition to operational difficulties, there are administrative difficulties in the terminal environment similar to those discussed for the en route environment when physical rearrangement of equipment is required.

#### 2.1.1 Current System Elements

The current A/G Communications System consists of the following elements and/or subsystems, in the approximate quantities of:

- S      560 Remote Communications Air/Ground (RCAG) facilities;
- S      1,200 Remote Communications Outlets (RCOs);
- S      800 Remote Transmitters/Receivers (RTRs).
- 2,500 radio sites,
- 10,000 frequency assignments, and,
- 40,000 crystal-controlled transmitters, receivers, or transceivers.

The following factors constrain the current system:

- S      Dedicated networks for each operational domain,
- Limited restoral capabilities,
- Analog fix-tuned AM main and standby transmitters and receivers,
- 25 kHz channel spacing,
- Tunable AM transceiver for back-up emergency communications (BUEC),
- Exhausted VHF and UHF ATC frequency bands, and

- Radios that are nearing the end of their useful life.

### 2.1.2 Current System Connectivity

With the current system, proper A/G connectivity is accomplished by a pilot manually tuning a radio. When a new frequency is assigned, it is verbally provided to the pilot.

The human interface with the A/G system is through the radio microphone using the same push-to-talk discipline as in today's system. This interface is a second level interface on the ground since the connectivity is through the switch located in the control site. In the aircraft, however, the interface is directly between the pilot and the transceiver. In both situations, the pilot and controller are responsible for tuning the radio to the proper frequency.

### 2.1.3 Current System Security

There is limited physical security in the existing A/G communications system ground facilities. In particular, some remote radio sites provide security from vandalism and theft through the use of intrusion alarms. The status of these alarms can be monitored using the Remote Maintenance Monitoring System (RMMS).

The information required to complete this section is to be provided as part of a future enhancement to this document.

## 2.2 Future System Architecture Overview

The remedy for the communications system deficiencies is to design and implement a new A/G communications system based on digital technology. The new communications system will support both voice and data communications and will enhance other characteristics of the A/G link. The upgrade to digital circuits and interfaces will support more rapid detection of failures and restoration of service. New digital radios for this system will utilize the new VHF standards when adopted by ICAO. Other ICAO states will also migrate to this new system, as the need arises, thus enabling the Future Air Navigation System (FANS) concept development. The basic system architecture for the Future Digital VHF A/G Communications System is illustrated by Figure 2-5.

With the implementation of the A/G digital communications system, controllers and pilots will be able to communicate transmissions simultaneously in the following three modes:

- Voice Communications - Used to communicate with the appropriate controller, other aircraft, or flight specialist.
- Receiving Broadcast Data - Recorded messages which provide current weather conditions and airport information.
- Two-Way Data Link - Supports information required to plan, monitor, and execute flight operations domestically and internationally. Information concerning traffic conditions, facilities, clearance, and weather will be available upon request.

Under the new communications system, ATC A/G communications will evolve from primarily voice to primarily data. Aeronautical VHF radio systems will transition to digital modulation to improve voice quality and increase channel capacity. VHF resources will be networked to make more efficient use of the resources and to support new capabilities, such as intrinsic back-up. Digital VHF capability will provide a third A/G data subnetwork (along with Mode S and satellite) for the ATN, increasing data communications capacity and reliability. Voice communications will continue to be used for emergencies, for non-routine communication and for those aircraft that are not data-equipped; AM voice will continue to be supported during the transition period.

Insert Figure 2-5, Future A/G Communications Ground System Architecture (old figure 2-2)

With communications equipment upgrades and the use of digital radios, quality voice, broadcast, data, and Flight Information Services will be provided to the user community. The envisioned services 37 include the following:

- Seamless environment with routine communications primarily via the Aeronautical Data Link System (ADLS);
- Navigation through Global Navigation Satellite System (GNSS) with Automatic Dependent Surveillance (ADS) reporting and differential corrections via ADLS;
- User evaluation of alternate flight path adjustments in real time;
- Optimized balance between air traffic demand and system capacity through interactive traffic flow management (TFM) exchange;
- Separation standards based on user needs and system capabilities (CNS, ADLS, and aircraft); and
- ADLS support to mix of aircraft equipage (voice still available).

Future A/G system functions will be allocated into three basic categories: voice functions, data link functions and environment functions (typically associated with operational domains).

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|---|---|
| <ul style="list-style-type: none"><li>• Voice Functions<ul style="list-style-type: none"><li>•• Air /Ground (A/G)</li><li>•• Ground to Ground (G/G)</li></ul></li></ul>   | <ul style="list-style-type: none"><li>• Data Link Functions<ul style="list-style-type: none"><li>•• Air /Ground (A/G)</li><li>•• Ground to Ground (G/G)</li></ul></li></ul> |
| <ul style="list-style-type: none"><li>• Environment Functions<ul style="list-style-type: none"><li>•• En route</li><li>•• Terminal</li><li>•• Tower</li><li>•• Flight Services</li><li>•• Oceanic</li></ul></li></ul> |   |

The Future Digital VHF A/G Communications System for ATC is based on a Time Division Multiple Access (TDMA) signal-in-space architecture. This architecture is depicted on Figure 2-6 and is designed to increase capacity, improve RFI immunity, provide increased security, and provide new radios with voice and data capability and RMM. In addition, the new system is designed to be backward-compatible with the existing system and is capable of evolutionary transition for ground and airborne equipment. The principal features identified by comparing the current system and the future system architectures are provided as part of this exhibit and include

both network and new radio features. The TDMA capability, technology and applications to the Future Digital VHF A/G Communications System are described in a number of documents (Source Numbers 15, 21, 22, 25, 26, 27, 28, 39, and 42) listed in Appendix A, Source References.

Insert Figure 2-6, The TDMA Concept (old figure 2-4)

The VHF TDMA system can additionally support discrete addressed voice and data link applications. The operational benefits of the TDMA approach are summarized as follows:

- Availability of real-time ATS voice and data for all users, including GA;
- Minimal "stuck-microphone," "walk-on," and "phantom controller" incidents;
- Consistent voice quality;
- Improved security and immunity to RFI;
- Reduced user workload;
- Increased flexibility for resectoring and network reconfiguration;
- Additional capacity for meeting the expected increase in A/G traffic; and
- Flexibility to use voice and data mixes.<sup>27</sup>

New features being assessed by controllers through working groups are presented as operational scenarios in detail (Section 5.0) and are listed in Table 2-1.

Table 2-1. New A/G ATC Features

Transfer of Communications	Reduction of Stuck Microphone Incidents	Reduction of Clipped and Blocked Transmissions (Controller Override)	Selective Addressing	Link Failure Detection and Correction	Link Security	Aircraft Identification (Caller ID)	Pilot Urgent Message Indicator	Channel Contention Limitor
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#### 2.2.1 Future System Elements

Figure 2-7 illustrates the primary elements of the Future Digital VHF A/G Communications System. The components of the communications system are the new digital radio and an interface unit at the radio site; a Ground Network Interface (GNI) to manage voice and data information at the control site; routers; and modems for transmission between the control site and the radio site. The functional architecture shown in the figure will be identical at all facilities with the exception of the voice switching system element.

At the ARTCCs, the Voice Switching and Control System (VSCS) is planned, while at the ATCTs and TRACONs the Enhanced Terminal Voice Switch (ETVS) will be used. Both of these switches will be digital voice switches with similar interfaces. Both the voice switch and the data router have A/G functions but they also serve G/G interfacility communications functions.

The primary purpose of the RIU is to manage several radio units at the radio site. This includes coupling transmitter and receiver units into a single duplex data stream for transmission over the modem. The GNI consists of voice and data interface units and represents the point of interface of the digital VHF A/G system to the other NAS systems.

For ATC, the basis selected for the A/G system from architecture enhancement alternatives is the VHF TDMA digital radio.<sup>26</sup> The communications system is presently in the requirements definition, design, development, and test stages. The planned system will provide spectrum

Insert Figure 2-7, Future A/G System Elements (old Figure 2-3)

efficiency, voice and data communications between ground facilities and aircraft in a single, flexible integrated system.

Digital radios will be installed on aircraft and at ground radio and control sites. At the radio sites, Radio Interface Units (RIUs) will interface with the aircraft radios. The VHF TDMA GNI and its constituent components will be installed at the control site for independent handling of the voice and data circuits provided by the digital radios.

The controller voice information is provided through the ETVS, VSCS, GNI and the radio site to the aircraft. Pre-Departure Clearances, Digital Automated Terminal Information System (ATIS), and Automatic Voice Generation (AVG) are provided through the Tower Data Link Services (TDLS). The TDLS will eventually evolve to the Tower Communications Command and Control (TCCC) in the late 1990's. An additional interface to the A/G system, the Data Link Processor (DLP), will be developed through a series of builds and will provide weather information, ATIS, and flight data through commercial service providers. A possible VHF data link alternate path to the aircraft will be determined. The Mode S interface will provide alphanumeric weather information. There are additional voice and data interfaces between the National Airspace Data Interchange Network (NADIN) and the TRACON, ACF, and MCF.

Voice information is provided through the VSCS and the AFSS. Data information flows through the Initial Sector Suite System (ISSS)/Display System Replacement (DSR), Host Data Link (HDL), DLP, NADIN and commercial service providers via satellites or possibly the VHF Data Link. The HDL provides en route ATC Two-Way Data Link (TWDL) using DLP. HDL provides controller/pilot exchange of ATC messages such as transfer of communications, change of aircraft position or altitude, and pilot downlink. The remote radio sites communicate with multiple aircraft and are controlled by the GNI. With the addition of the digital radios, improved air-to-air connectivity can occur. The ACF controller provides flight information, separation instructions, frequency information, and can direct air-to-air communications if required. Automated flight information can also be provided through the AFSS.

### 2.2.2 Future System Connectivity

A description of the external and internal A/G system interfaces is provided in this section based upon known elements of the Future Digital VHF A/G Communications System. As the system concept and equipment mature, physical and electrical interfaces will be described in subsequent Interface Requirements Documents (IRDs). There are three primary connectivities associated with the future A/G system: the external connectivity with the other NAS systems; the internal connectivity ground-to-air and air-to-ground; and the internal air-to-air connectivity.

Reference documents listed in Appendix A provide additional sources of detailed technical descriptions of the future system and its interfaces. At this time, the system engineering

documentation (IRDs, ICDs, and system specifications) are still under development. The TDMA capability, technology and applications to the Future Digital VHF A/G Communications System are described in a number of documents (Source Numbers 15, 21, 22, 25, 26, 27, 28, 39, and 42) listed in Appendix A, Source References.

#### 2.2.2.1 External Connectivity

The single point of interface between the systems of the NAS and the A/G system is the GNI. Voice interface with the GNI is between the VSCS in the ACF; the ETVS in the ATCT, in the TRACON, and in the MCF; and the voice switch with an analog/digital (A/D) converter in the AFSS. Voice and radio control signals from these switches are processed through the GNI and then transmitted via ground lines to the RIU. The RIU then sends the voice information to the proper radio, and path to the aircraft is accomplished using the new TDMA Digital Radio.

The data transmission path is indirect. Generally, the future system will acquire data primarily from the ATN; however, there will be a direct data transmission capability in the digital VHF system, in the broadcast data link mode. In most cases, data will be routed through the ATN and DLP, from towers, TRACONs, en route facilities, and flight service stations. Appropriate data will be routed to the GNI for transmission to the RIU and then over the digital radio to the aircraft. The aircraft avionics are expected to contain an ATN router interface with the airborne TDMA transceiver since data from other sources must be routed to other avionics systems.

The question remains as to whether an alternative route for broadcast data transmission will be identified that does not require routing through the ATN and/or DLP. One of the advantages of the VHF A/G system is that it can support VHF voice and data broadcast from data sources outside of the ATN. This issue is currently being addressed by a number of industry organizations and the FAA. The TDMA capability, technology and applications to the Future Digital VHF A/G Communications System are described in a number of documents listed in Appendix A, Source References.

#### 2.2.2.2 Internal Air-to-Ground and Ground-to-Air Connectivity

The three principal points of internal interface and connectivity are between the Control Site, the Radio Site, and the Controlled Site. Figure 2-7 illustrates the internal A/G system elements. Within the control site, the Network Interface Unit interfaces with modems in order to transmit the voice and data information to the Radio Site. Note that the interface between the GNI and the voice switch and data router are discussed above as external A/G system interfaces.

The modem at the control site communicates with a modem at the radio site and the voice and data information are transmitted over ground transmission media to and from the radio site. Leased lines are often used for this purpose. At the radio site, the modems interface with the

radio interface unit which manages the several radios at the radio site including coupling transmitters and receivers and switching of radios in response to control signals from the control site. The transmitters and receivers at the radio site are used to send and receive information from the aircraft. A transceiver located in the aircraft interfaces with the ground radio site and the ATN router. The function of the aircraft ATN router is to route the data information to and from the proper avionics aboard the aircraft.

The TDMA capability, technology and applications to the Future Digital VHF A/G Communications System are described in a number of documents (Source Numbers 15, 21, 22, 25, 26, 27, 28, 39, and 42) listed in Appendix A, Source References.

### 2.2.2.3 Internal Air-to-Air Connectivity

The final element of connectivity associated with the A/G system is air-to-air connectivity. There are three operational cases that will be considered in which air-to-air connectivity is important:

- Party Line
- Lost Aircraft
- Ground Failure

In today's system, all pilots on the same radio frequency hear the communications between the other pilots and the controller on that frequency. This provides the pilot with an awareness of what is occurring in the airspace of the proximity of other aircraft, providing an important safety element in today's ATC system. Technology has, however, introduced TCAS and situation displays in the cockpit that may mitigate the loss of this "party line picture." Use of discrete address data link for ATC clearances will compromise the party line picture as will the new TDMA voice system.

In the new TDMA A/G system the air-to-air connectivity via this party line will not exist to the same extent, primarily because of the subdivision of the 25 kHz frequency into four equivalent subchannels. If voice communications are used on more than one subchannel, only those pilots that are tuned to the same subchannel will hear each other. Direct air-to-air connectivity does, however, exist for voice due to the single frequency nature of the TDMA channel but only for those in the same talk group.<sup>29</sup> This case could result in severe degradation of performance if the master timing source originates on the ground.

In the case of "lost aircraft," the airborne user will lose contact due to line of sight (LOS) limitations. A possible solution consists of a "relay" technique within the ATC service volume. For uplink messages, ATC designates a "relayer" in proximity to the lost aircraft. For downlink messages, the lost aircraft will automatically establish timing from monitoring transmissions from proximate aircraft.<sup>29</sup>

Finally, the case of complete failure of the ground elements of the A/G communications system could be caused by a catastrophic event where both primary and secondary ground sites are lost. In this situation, all talk groups will share the full 25 kHz channel in analog or in digital operation. This could be the last assigned channel or a pre-designated air-to-air channel reserved for emergency purposes.<sup>29</sup>

#### 2.2.4 Security

There is limited physical security in the existing A/G communications system ground facilities. In particular, some remote radio sites provide security from vandalism and theft through the use of intrusion alarms. The status of these alarms can be monitored using the RMMS. It is expected that this same and a possibly improved level of security will be associated with the new remote A/G radio sites since they will be designed to be fully compatible with the RMMS. In addition, the future system will provide for link security, link monitoring, and failure reporting. These new TDMA features are described and illustrated in Section 5.0. The TDMA capability, technology and applications to the Future Digital VHF A/G Communications System are described in a number of documents (Source Numbers 15, 21, 22, 25, 26, 27, 28, 39, and 42) listed in Appendix A, Source References.

One particular problem in the existing system is the occasional "phantom controller." At times an unauthorized person using a portable transceiver can tune to the ATC frequency and can transmit control commands to an aircraft after listening in on the frequency to the controller-pilot transmissions. One method of avoiding this problem, given the digital nature of the new TDMA approach, consists of introducing a public key or other encryption technique that would encode transmissions at one end of the communications string and would decode the transmissions at the other end of the transmission string. This new TDMA feature is described and illustrated in Section 5.0.

The information required to complete this section is to be provided as part of a future enhancement to this document.

### 2.3 Transition to the Future System

Since many key transition issues are yet to be determined, it is not possible to present detailed transition descriptions at this time. When the evolution of the future system is more clearly defined, the transition sections required will be provided.

### 2.3.1 Transition Considerations

The future A/G communications system will be implemented in a phased approach, transitioning from the current analog system to a full digital operation. The transition will occur on three levels: an operational level; a ground infrastructure level; and a frequency management level.

The information required to complete this section is to be provided as part of a future enhancement to this document.

### 2.3.2 Operational Transition

An overriding requirement for the Future Digital VHF A/G Communications System is that the transition to the future system must not evidence any significant operational changes, except for improvements in operational efficiency resulting from the implementation of new functions. The system may be initially implemented to support voice-only (analog and digital) service in order to increase spectrum efficiency. The operational transition for the users is intended to be nearly transparent and will support discrete addressed voice and data link applications.

The information required to complete this section is to be provided as part of a future enhancement to this document.

### 2.3.3 Ground Infrastructure Transition

Major new equipment will include the digital radio and its interfaces. In an initial voice-only implementation, the digital mode can be configured with analog and signaling interfaces compatible with the current A/G radios. Ultimately, a digital ground infrastructure will be put in place to replace the analog transmission media between the control site and the radio site.

Transition to the digital radio will probably begin in the high-altitude en route sectors. Next in line for transition will be the low-altitude en route sectors and the terminal radar control positions serving major high traffic airports. Finally, the last segments may be the FSS and smaller ATCTs due to their high general aviation component.

The information required to complete this section is to be provided as part of a future enhancement to this document.

### 2.3.4 Frequency Management Transition

In order to develop the next-generation Future Digital VHF A/G Communications System, the FAA and the international community must be able to expand the number and utilization of A/G circuits needed by controllers and pilots in the coming years. The TDMA architecture will greatly

improve the spectral efficiency of the system by supporting more A/G circuits with the currently available frequency spectrum. It will be necessary to convert the existing A/G radio system to TDMA operations by means of a non-disruptive transition process.

The information required to complete this section is to be provided as part of a future enhancement to this document.